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PRE-PROCESSING TECHNOLOGIES TO PREPARE SOLID WASTE FOR COMPOSTING

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ABSTRACT

The organic constituents of municipal solid waste can be converted into compost for use as a safe, beneficial soil amendment, conserving landfill space. The solid waste must first be processed to remove contaminants and prepare the organics for composting. This paper describes five different pre-processing systems, covering a broad range of technical approaches. Three are described briefly; two, from projects managed by the author, are presented as more detailed case histories: 1) a pilot study at a refuse-derived fuel (RDF) plant in Hartford, Connecticut and 2) a solid waste composting facility in East Hampton, New York. Materials flow diagrams and mass balances are presented for each process, showing that 100 tons of solid waste will yield 32 to 44 tons of compost, requiring disposal of 3 to 10 tons of metal, grit, and glass and 16 to 40 tons of light residue that can be landfilled or used as RDF.

INTRODUCTION

Beginning in the late 1980s, a number of states enacted legislation mandating the diversion of certain percentages of the solid waste stream from landfilling. One result was an increased interest in solid waste composting and the construction of approximately 20 facilities around the Country. Many of these plants utilized proprietary technologies developed in Europe, where there was more experience with complementary production of compost and RDF from the same solid waste. Other processes were developed for the American situation, where there is less market for RDF.

The purpose of this paper is to demonstrate the range of processing technologies that are utilized to prepare solid waste for composting with and without simultaneous production of RDF.

WASTE MATERIALS WHICH MAY BE COMPOSTED

In general, the following materials in typical solid waste may be composted:

- Food waste
- Paper
- Diapers
- Yard waste

In addition, sewage sludge may be beneficial to the composting process and may be incorporated at relatively little incremental cost. Paper is generally recovered and recycled to the greatest practical extent, as recycling provides more revenue at less cost than composting. However, much of the wet or mixed paper is not being recycled. Processes that extract both RDF and composting feedstock are generally operated to maximize the paper in the RDF. Food waste and non-recyclable paper generally constitute approximately 25 to 35 percent of the waste stream. The quantity of yard waste varies greatly depending on the landscape of the community and how yard waste is collected. On the average, yard waste constitutes an additional 17 percent (Cal Recovery, 1993).

OBJECTIVES OF PRE-PROCESSING

The following objectives must be met in preparing solid waste for composting.

Size Reduction

The optimal particle size is typically in the range of two to eight centimeters to provide a high volume to surface ratio. Microbial decomposition takes place on particle surfaces.

Removal of Contaminants

Contaminants include light materials such as film plastic and textiles, dense materials such as glass, and ferrous and non-ferrous metals. Typically, they are removed by a combination of pre-processing and refinement after composting.

Adjustment of Moisture and Nutrient Content

The feedstock should have a water content in the range of 55 to 60 percent and a ratio of available carbon to nitrogen (C:N) of 30 to 40. Paper is high in carbon. Food and sludge are high in nitrogen. If the C:N ratio is too high, as is frequently the case with mixed solid waste (MSW), the decomposition of carbonaceous material is inhibited. It is also essential that the materials be thoroughly mixed and wetted.

There are a number of approaches to meeting these objectives. They will be illustrated through descriptions of existing facilities.

EXAMPLES OF PRE-PROCESSING AND COMPOSTING SYSTEMS

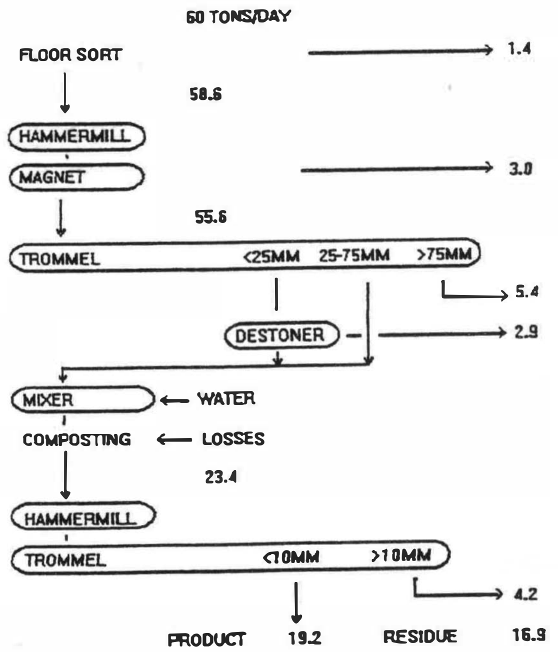
General Method of Reporting

The materials balances for the following three facilities were derived from communications with the facility operators. It was necessary to back-calculate or estimate some of the tonnages to supplement existing records (Gould, et. al., 1994). The tonnages reported herein may not reflect the full range of operating conditions that have occurred over time. Tonnages are metric unless otherwise noted. Screens are described by nominal cut size, and the metric to English equivalents may not be exact.

Prairieland Resource Recovery Composting Facility - Truman, Minnesota

This facility treats 50 to 59 tons (55 to 65 U.S. tons) per day using the OTVD processing technology, which is provided by Omnium de Traitements et de Valorisation. Unlike most other composting systems, this process begins with shredding using a vertical single-shaft hammermill. Next, a trommel splits the waste into three fractions. The small, dense, inert particles are removed from the fine fraction before instead of after composting. The destoner removes these particles on an inclined vibrating deck screen through which air is blown upward. The heavy particles are thrown up the incline; the organic material slides down, fluidized by the air; the fine dust is picked up by a suction system. The advantage of the hammermill is that most of the waste is shredded to a small enough size that it can be processed in a destoner ahead of composting. The disadvantage is that batteries, paint cans, and other contaminants are pulverized and forcefully mixed into the feedstock. Hammermills must be isolated and vented to prevent the risk of explosion damage.

FIGURE 1
PRAIRIELAND, MINNESOTA
PROCESS: OTVD



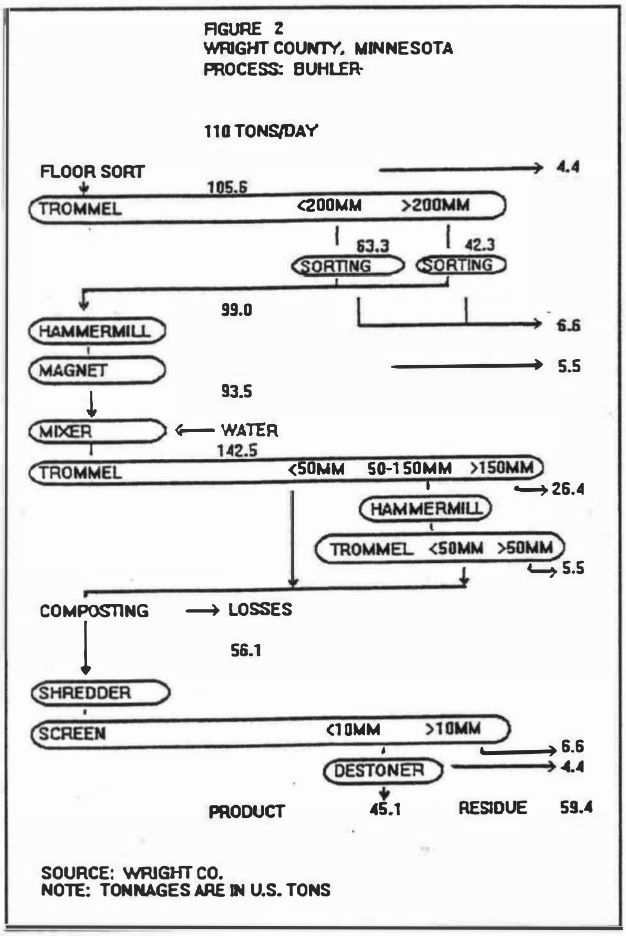
SOURCE: PRAIRIELAND
NOTE: TONNAGES ARE IN U.S. TONS

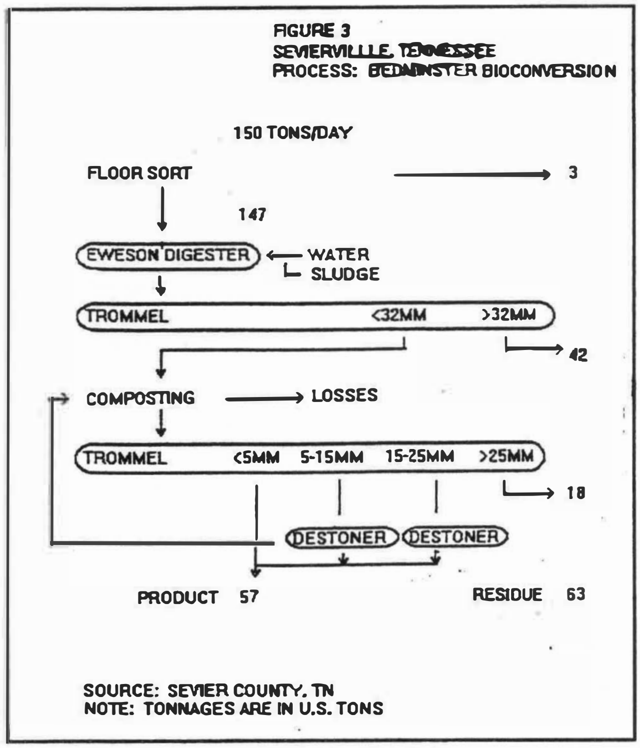
The OTVD composting process consists of parallel agitated beds separated by concrete walls. An agitator rides on rails and transfers the material from one bed to the next with each turning. Following composting, the material is shredded and screened. Figure 1 shows the processing sequence and materials balance. At an OTVD facility in Plufragon, France, the over-sized fraction from the trommel is incinerated on-site as RDF.

Wright County Composting Facility - Monticello, Minnesota

This facility pre-processes 100 tons (110 U.S. tons) per day and composts a total of 150 tons (165 U.S. tons) per day, the remainder coming from a facility in Eden Prairie. This technology at both facilities is provided by Buhler-Miag. The first step of pre-processing is a trommel followed by manual removal of rejects and recyclables. The plus 20-centimeter/minus 20-centimeter split makes sorting easier, as it is difficult to remove small items from a belt carrying cardboard and other large materials. The material is shredded and mixed with water in a long mixing drum with 30 minutes of detention time. Until cutting baffles were installed in the drum, material would wind into "snakes," despite having been shredded.

The Buhler composting process consists of aerated windrows periodically agitated by a windrow turning machine. The





windrows are aerated by drawing air down into aeration trenches in the floor. The exhaust air is treated for odor removal. Following composting, the material is refined by a shredder, trommel, and destoner. Figure 2 shows the processing sequence and materials balance. The material is not shredded until recyclables and contaminants have been manually removed. Manual sorting can be efficient if large and small materials are sorted separately. The remaining paper is pulped in the drum, and material such as film plastic and textiles that cannot be pulped or easily shredded are removed in the trommels. Unlike with the OTVD process, glass is removed after composting.

Sevier County Composting Facility - Sevierville, Tennessee

This facility receives 159 tons (175 U.S. tons) per day of municipal solid waste plus 86 tons (95 U.S. tons) per day, on a wet-weight basis, of dewatered sludge. The technology is provided by Bedminster Bioconversion. There is no shredding. The materials are mixed for three days in insulated drum digesters. Each day the material is passed in a batch to the next chamber. The digester pulps the organic material, initiating the composting process. This facilitates the removal of non-biodegradable materials as a plus 32-millimeter (1.25-inch) fraction. Most rejects come out in this stage. The drum digester combines size reduction and adjustment of moisture and nutrient content in a single stage while facilitating the removal of non-biodegradable materials. Because these materials are wet, they are not optimally suitable as RDF.

Composting takes place in aerated piles which can be turned periodically. A system of mechanical agitation will be added in the future. The compost is refined on a multi-stage trommel that divides the product into three particle size ranges, each of which is processed in a separate destoner. Destoners are most efficient when operating within narrow particle size ranges. Figure 3 shows the processing sequence and materials balance.

CASE STUDY - THE MID-CONNECTICUT PROJECT

Background

The mid-Connecticut Waste Processing Facility in Hartford, operated by the Connecticut Resource Recovery Authority (CRRA), receives 9,090 tons (10,000 U.S. tons) per week of solid waste which is processed into RDF and combusted in a pre-existing power plant. Figure 4 shows the waste processing sequence and materials balance. The processing system consists of two parallel processing lines, each rated at 91 tons (100 U.S. tons) per hour with approximately 23 percent down time. The flailmill is similar to a horizontal shaft hammermill, but it does

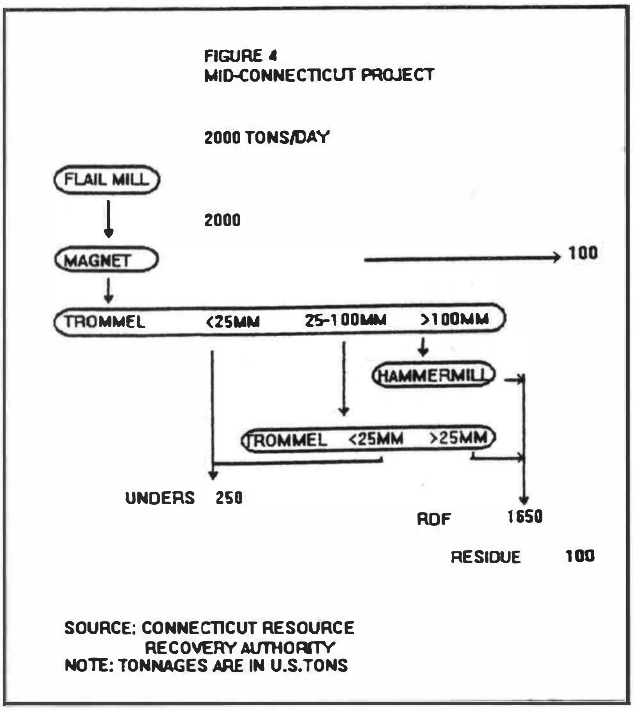


FIGURE 4
MID-CONNECTICUT PROJECT

SOURCE: CONNECTICUT RESOURCE RECOVERY AUTHORITY
NOTE: TONNAGES ARE IN U.S.TONS

not have a grate. Heavy and brittle materials are shredded, but plastic, paper, and textiles receive less size reduction. Each flailmill has 500 horsepower. Each hammermill has 1,000 horsepower with a 10-centimeter (4-inch) grate. The secondary trommel removes relatively little and could be eliminated if the primary trommel is large enough.

The residue, or RDF unders, is a mixture of grit, glass, and putrescible material with a relatively high moisture content. The RDF appears to contain food, yard waste, glass, grit, and styrofoam packing. The RDF unders are landfilled. In 1990, E&A Environmental Consultants, Inc. (E&A) was engaged by R.W. Beck Associates to evaluate the technical and economic feasibility of converting the RDF unders into compost which could be used as landfill cover, displacing the purchase of cover soil and conserving landfill capacity.

The Pilot Study

A pilot study was conducted composting two 25-cubic-meter (32-cubic-yard) batches of RDF unders at EarthGro in Lebanon, Connecticut. One batch was pure RDF unders with the water content adjusted, and the other was a blend of RDF unders and leaves. EarthGro operates aerated horizontal bed reactors converting yard waste, manures, and other organic feedstocks into bagged topsoil products. The reactors provide cycled aeration of the compost feedstock controlled by temperature feedback combined with daily agitation for a detention time of 21 days. The most significant findings of the pilot study are summarized below:

TABLE 1 - COMPARISON OF METALS CONCENTRATIONS (MG/KG DRY WEIGHT)

Metal	Part 503 EQ Limits	CRRA RDF Unders	CRRA RDF Unders & Leaves	East Hampton	Published Data (Epstein, et. al., 1992) Mean Range
Arsenic	41	2.9	3.3	0.3	2.6 1-4.8
Cadmium	39	3.5	3.8	0.6	2.9 1-13.2
Chromium	1,200	330	367	10.5	34.8 8.2-130
Copper	1,500	517	541	42	154 31-623
Lead	306	739	831	65	215 22-913
Mercury	17	10	10	1.9	1.3 0.5-3.7
Nickel	420	267	283	5.4	24.8 7-101
Selenium	36	5.0	5.0	0.25	NM NM
Zinc	2,800	738	657	NM	503 152-1,363

NM - Not measured

- Normally, the optimal water content for composting is 55 to 60 percent. With RDF unders, the optimal water content is lower because of the high proportion of glass, grit, and other non-absorptive materials.
- Temperatures rise more slowly and less energy is generated than with typical feedstocks, again due to the high proportion of inert materials.
- The compost is sufficiently stable for landfill cover after a combined composting and curing time of 60 days. For horticultural use, 70 to 90 days would be required.
- The process is odorous for the first 35 days.
- The compost contains glass particles and plastic. It is adequate for landfill cover but would require further refining for other applications.

Table I shows the average concentration of metals in the CRRA compost as compared with limits in the EPA Part 503 Regulations (503s) for compost for general distribution, termed EQ, or "exceptional quality." The 503s apply to composted feedstocks containing sewage sludge.

The first column shows allowable metals concentrations under the 503s for compost that can be distributed or utilized without site restrictions. The CRRA compost is in compliance for all metals except lead. These concentrations are averages of batches with and without leaves. Surprisingly, the leaves did not have a diluting effect. This may have been due to street sweepings in the leaves. Other columns are referenced in later sections of this paper.

The conclusion of the study was that the compost would be suitable for landfill cover and that for the CRRA, composting would be a cost-effective means of managing RDF unders, given the value of landfill capacity (R.W. Beck Associates, 1992). At this time, full-scale implementation is still being considered (CRRA, 1995).

CASE STUDY - THE EAST HAMPTON COMPOSTING FACILITY

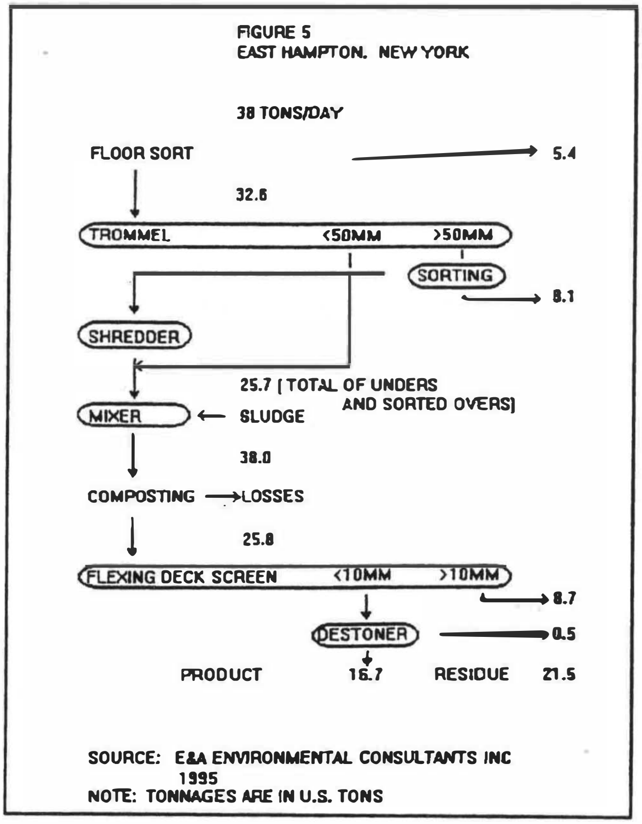
Background

The Town of East Hampton, New York encompasses the area from Montauk to Sag Harbor on Eastern Long Island. Faced with the closure of their landfill and high costs of hauling waste out of town, East Hampton developed a solid waste management plan, emphasizing intensive recycling and composting of source-separated organic waste (SOW). SOW would consist of food waste, non-recyclable paper, diapers, the small amount of yard waste collected with household refuse, and sewage sludge. The Town has a full-time population of 16,000 residents but a summer waste flow equivalent to a population of 65,000 people. This has an impact on developing a cost-effective waste management system. In 1990, E&A completed the Town's solid waste management plan and then collaborated with L.K. McLean & Associates on the design of an integrated solid waste management facility. Construction was substantially complete, and start-up began early in 1995.

The East Hampton Disposal Facility includes the following components:

- Drop-off area - Over one-half of East Hampton residents deliver their own waste to two Town facilities, sorting it into a number of bins, including one for SOW.
- Sorting and baling area - This area is for the recycling of fiber and containers.
- Composting facility sized for 32 tons (35 U.S. tons) per day - This is the projected quantity of SOW in the peak summer season. In the off-season, the plant can handle the full flow of MSW to increase its rate of utilization.
- Transfer station - This area is for the hauling-out of residential waste.

Commercial SOW will be collected separately. Residences using carters will put their SOW in a clear bag and residual



waste in a black bag. Both bags will be collected in the same packer load, and the bags will be separated at the facility. So far, this component of the program has not been initiated.

Operation of the Composting System

Figure 5 shows the sequences for pre-processing of composting feedstock and refining of compost with materials balances. The pre-processing system has a design capacity of 6.4 tons (7 U.S. tons) per hour. Bags will be separated on the tipping floor by laborers and a skid steer loader. In a larger facility, the mixed load would be fed onto a belt for more productive separation. The trommel opens and empties the bags and separates minus 5-centimeter (2-inch) material. The 240-centimeter (8-foot) diameter by 900-centimeter (20-foot) long trommel is 90 percent efficient in emptying bags at design flow. The plus 5-centimeter (2-inch) material is sorted manually to remove the film plastic, textiles, easily recovered contaminants, and items that would foul the shredder.

The shredder is a low-speed shear shredder with 3.8-centimeter (1.38-inch) knives with multiple hooks to maximize size reduction. A shear shredder was selected because it can be located within the facility without explosion hazard or excessive noise. The shredder produces 3.8-centimeter-wide strips of varying length. This degree of shredding is adequate because the composting process provides daily agitation with further size reduction.

The shredded and the minus 5-centimeter (2-inch) fraction are re-combined and passed under a magnetic separator. A single-stage magnet picks up a large amount of paper and plastic with

TABLE 2 - RESIDUE AND NET YIELD OF COMPOST AS PERCENTAGES OF SOLID WASTE INFEED

Facility	Heavy Residue	Light Residue	Compost Net Yield
Prairieland	9.8	16.0	32.0
Wright County	9.0	21.4	41.0
Sevierville	~0	30.7	38.0
East Hampton	3.4	38.9	43.9

the ferrous metal, so this fraction would not be suitable for recycling without further refinement. Next, the feedstock is mixed with sewage sludge in batches in a 13.9-cubic-meter (18-cubic-yard) SSI mobile compost mixer. The mixer has load cells to permit accurate proportioning of feedstocks. When operating with MSW instead of SOW, livestock manure is also added to provide supplemental nitrogen.

The composting process was developed based on the previously referenced CRRA pilot study. The horizontal agitated bed process is used with a 30-day detention time with the ability to add water after 10 and 20 days. This is critical, as solid waste composting tends towards excessive drying. Following up to 12 weeks of curing, the compost will be refined. The refining system has not yet been installed but will consist of a 10-millimeter (0.38-inch) trommel and a destoner. The plus 10-millimeter fraction, consisting of film plastic and other non-biodegradable materials, is residue. The destoner is critical because there is no provision for removal of glass in pre-processing. The losses in composting were calculated from the reduction in percent volatile solids and moisture. The materials balance for refining in Figure 5 is based on analyses of the cured compost and performance specifications used in procurement of the refining system. Table 1 shows that the East Hampton compost metals concentrations are well within the 503 limits.

SUMMARY AND CONCLUSIONS

The last columns in Table 1 show the ranges of published heavy metals concentrations in solid waste compost. The only metal for which the upper end of the range exceeds 503 EQ limits is lead. Lead is the metal most likely to exceed allowable limits at most operating composting facilities in the United States.

Table 2 summarizes the percentages of solid waste entering each of the processing systems which are removed as heavy residue (glass, grit, metals, etc.) and light residue (film plastic, textiles, un-composted paper, etc.). The table also shows the net yield of compost as a percentage of solid waste entering the system. The calculation is complicated by the addition of water or sludge. If light residue is separated from compost feedstock by wet pulping as in the Buhler and Bedminster processes, the weight of the residue is increased. Although adjustments were made for water addition in calculating the percent of light residue, the number is subject to a wide range. At East Hampton, much of the heavy residue is removed in manual sorting and is, therefore, counted as light residue. At Sevierville, the glass and grit removed by the destoners can be recirculated into composting, where it is eventually ground up and becomes undetectable. Despite the wide range in percentages of residue, the net yield of compost falls within a much narrower range.

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